AGEING STUDIES OF NATURAL RUBBERS USED IN SPACE APPLICATION

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Thanks to their high tensile strengths and excellent dynamic properties, natural rubber compounds are commonly used in a variety of technical applications, satellites in particular. The rubber should fulfill the space technology requirements during all the lifetime of the satellite which is of 15 years: 5 years of storage at ground and 10 years in space environment.

However, some properties such as air permeability, thermal resistance and damping capacity could be hugely modified during the lifetime of the material.

The study of these materials ageing is also essential in terms of research. The objective of this work is to investigate the ageing of natural rubber filled with carbon black particles under two kinds of stress: temperature (70°C) and vacuum (5.10^{-6} mbar).

Thermal ageing at 70°C under air (oxidative conditions) and high vacuum (non oxidative conditions) was first investigated. It was shown that the static and dynamic mechanical properties, such as for example the tensile strengths at 20 and 50% of elongation were greatly increased during oxidative ageing (Figure 1). These modifications of the material properties could be explained by an increase of the crosslinking density. This hypothesis was confirmed by swelling measurements (before and after ageing) which allowed an estimation of the crosslinking density thanks to the Flory-Rehner equation.

At the opposite, the strengths at 20 and 50% of elongation did not change during 22 days of ageing at 70°C under vacuum.

Then, the oxidation effect on the mechanical properties was studied by using Atomic Force Microscopy (AFM). Force measurements showed that the elastic modulus of aged rubber (184 days at 70°C) is higher at the surface than in the bulk. These results could be explained by the formation of a highly oxidized thin layer at the material surface during ageing. The evolution of this layer thickness during ageing was estimated thanks to AFM measurements.

In addition, Scanning Electron Microscopy observations coupled with Energy Dispersive X-ray (SEM-EDX) analyses were carried out in order to investigate the evolution of the morphology and the chemical structure of the rubber during ageing.

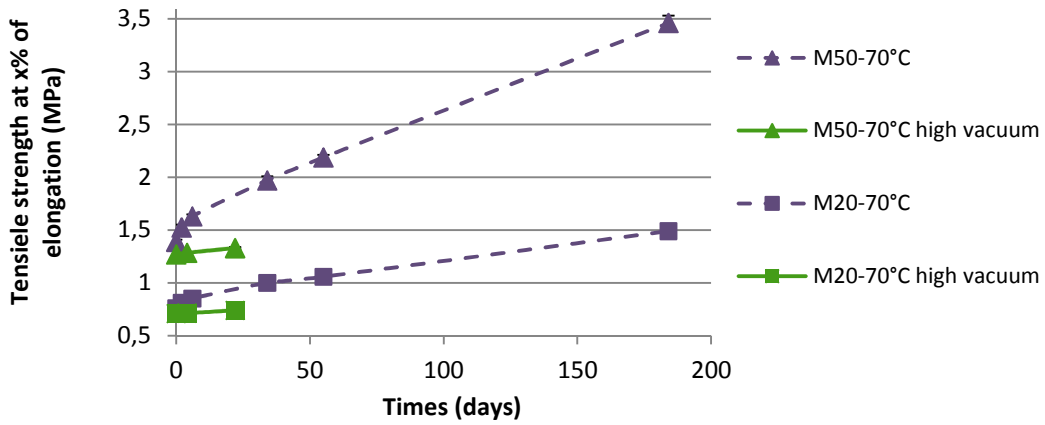

Figure 1 Variation of the tensile properties of natural rubber exposed at 70°C in air versus ageing duration.